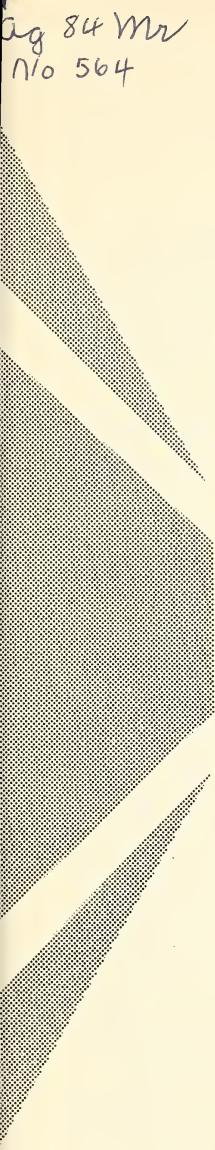


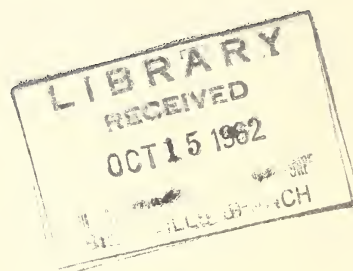
Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

ag 84 Mr
No 564



LABOR AND CAPITAL for Mixing FORMULA FEEDS



Marketing Research Report No. 564

Marketing Economics Division
Economic Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

PREFACE

This is the second of a group of research studies made by the U. S. Department of Agriculture to analyze the important phases of the overall feed manufacturing process. "Labor and Capital for Pelleting Formula Feeds," Marketing Research Report No. 463, was the first. The present publication is concerned with the heart of the entire manufacturing process: The mixing center. Major attention in these studies was given to setting reasonable standards for equipment and labor.

Work of this type is part of the Departments' broad program of research to expand market outlets and increase efficiency in marketing farm products. The farmer has double interest in this industry's efficiency since he produces the feed ingredients and also purchases the feeds.

CONTENTS

	Page
Summary	ii
Introduction	1
The Mixing Center	2
Definition	2
Mixing Systems	2
Flow Diagram	4
Operating Duties	6
The 80-Ton Model Center	7
Equipment	7
Operating Costs	9
The 200-Ton Model Center	13
Equipment	14
Operating Costs	14
Automatic Weighing Equipment	19
Implications of Findings for Management Decision	20
Established Plants	22
Building New Plants	23
Appendix	25
Premix Preparation	25
Use of Liquids	26

October 1962

SUMMARY

This study provides the mixed feed industry with information on standards for costs, labor, and equipment in two models of mixing centers with capacities of 80 tons and 200 tons per shift per day. The models were developed from records of feed manufacturers in 34 States. All of the manufacturers supplying data have been enrolled in the Feed Production School sponsored by the industry, making their recordkeeping comparable. Semiautomatic batchmixing equipment is used in the models.

Equipment for the mixing center of the model plant producing 80 tons of mixed feed per 8-hour shift costs about \$49,131. Labor requirements are 10.16 man-hours per shift, and annual operating costs, assuming 260 days of operation, are \$16,702. Mixing costs are about 80 cents a ton. If this plant is operated 16 hours a day, mixing costs drop to 70 cents a ton.

For the 200-ton model plant, mixing department equipment costs about \$79,858; annual operating costs are \$32,756; and labor requirements are 16.32 man-hours per 8-hour shift. The mixing center has an average operating cost of 63 cents a ton if the plant operates one shift daily and 55 cents a ton if the mill operates 16 hours a day.

The smaller model can mix as much feed in 20 hours of operation as the larger model can in 8 hours, but at this volume (52,000 tons) the large plant has a cost advantage of about 12 percent. In addition, the larger model permits further expansion of production at still lower average operating costs. Thus, for the mixing center, when volume begins to exceed 80 tons a day the longrun advantage seems to be with the larger model.

This relationship may be changed if fully automatic batch-weighing equipment is used. Capital would be replacing labor and would increase the capacity of the plants. If the smaller model operated only one 8-hour shift, the added capital cost could not be offset easily by reductions in labor costs. However, if the mill operated two shifts it is quite possible that the added capital costs would be offset by savings in labor costs.

LABOR AND CAPITAL FOR MIXING FORMULA FEEDS

Carl J. Vosloh, Jr., agricultural economist
Marketing Economics Division
Economic Research Service

INTRODUCTION

The mixed feed industry has changed markedly since World War II in response to many economic and technical developments. Farmers have increased their demands on the industry for both feeds and services. According to the U. S. Census of Manufactures, mixed feed production increased 36 percent from 1947 to 1958 (table 1). Farmers not only have shifted, in large numbers, from home-produced feeds to commercial feeds, but they have insisted increasingly on buying the improved-quality mixed feeds made possible by advances in knowledge of animal nutrition. Farmers have also continued to seek low-cost feeds and more services, reflecting to the industry the strong economic pressures on agriculture.

Table 1.--Prepared animal feeds industry: Feed manufactured, and number of establishments and employees, selected census years

Year	: Feed : manufactured	: Establishments	: Employees	
			Production	All
	<u>Tons</u>	<u>Number</u>	<u>Number</u>	<u>Number</u>
1947.....	23,060,000	2,688	40,115	55,152
1954.....	27,611,000	2,292	41,290	59,890
1958.....	31,352,000	2,379	38,010	57,313

U. S. Bureau of the Census. Census of Manufactures. Bulletin MC--20-D, Grain Mill Products. Issued for 1947, 1954, and 1958.

Changes in the location of major livestock and poultry producing areas in the United States have forced the mixed feed industry to move also. This geographic movement toward major feed-consuming areas and the increasing demands on the industry for more services have contributed to greater decentralization of the industry. And the industry has become even more consumer oriented.

At the same time, new developments in technology have contributed, along with changes in the product and in service requirements, to pressures on the industry to alter plant design, equipment, and operations. New technology and equipment have also made possible improvements in operating efficiency. From 1947 to 1958, while total output of the industry rose 36 percent, the number of plants fell about 10 percent and the total number of employees increased only 5 percent. In other words, output per plant and per employee has increased sharply.

These persistent and powerful trends and the highly competitive structure of the industry continue to create urgent demands for research to find feasible means of adjusting feed mixing operations to a constantly changing economic and technical

environment and to find practical means of increasing both technical and economic efficiency. Members of the industry repeatedly have asked for useful standards of costs and efficiency for all aspects of feed manufacturing operations.

This study was designed to meet some of these demands for information useful to owners and managers of feed mixing plants in making important decisions affecting operating practices and efficiency. More specifically, this study is concerned with the heart of the feed manufacturing operation, the mixing department. Data for the study were obtained by mail questionnaires and by personal interviews with feed manufacturers in 34 States. All of these manufacturers have been enrolled in recent years in the Feed Production School, Inc., a training institution sponsored by the feed industry. Most of these plants use the recordkeeping procedures recommended by the school. This practice greatly increases the comparability and usefulness of the data from these plant records and decreases research costs and difficulties. Some additional information was obtained from manufacturers of feed mill equipment. These data were used to develop the specifications of two model feed mixing centers.

This report sets forth in detail the labor and equipment requirements, the investment and operating costs, and standards for labor and equipment usage for a model mixing center with a capacity of 80 tons per 8-hour day and for a model with a 200-ton capacity. The standards are believed attainable by nearly all plant managers.

THE MIXING CENTER

The mixing department includes: (1) the movement of basic ingredients out of storage, (2) weighing of these ingredients, (3) the mixing, scalping, and blending operations, and (4) the movement of mixed feeds out of the department to storage or to the bulk distribution docks. The storage and loading-out operations, however, are not part of the mixing center.

Definition

The following definition of the mixing center was used by survey plants for supplying plant data on a uniform basis:

The mixing center begins after the point of storage of the ingredients used in mixing.

The work includes moving all materials into the mixing area, weighing bulk and trace ingredients, opening and dumping bagged ingredients, and the actual mixing of the feed. It also includes the addition of liquids to the feeds and the preparation of premixes. The last operation is the movement of all mixed feed into holding bins or to the scales for packing.

The mixing center ends as the mixed feed comes to rest in holding bins.

Mixing Systems

There are two basic methods of mixing formula feeds -- continuous mixing and batch mixing. Although the continuous-mix plant when properly equipped offers a potential of production and quality that is difficult to surpass, many of the smaller

plants constructed in recent years have batch-mixing units. Batch mixing has become popular in the mixed feeds industry for several reasons:

1. Batch units are more readily adapted to smaller plants.
2. Batch units can cope better with a wider range of formulations.
3. Adaptation of automation and maintenance of equipment are easier with batch units.
4. Operators of batch units need not be as skilled as operators of a continuous mix system.

Although continuous-mix units produced the bulk of the feed sold across the country in the past, batch units have become more widespread in new plants. Currently, few continuous systems are being built, despite their relative efficiency of operation.

Since the batch mixing systems are increasing in popularity this report will deal only with these systems. More specifically, the semiautomatic batch system has been used in the model mixing centers discussed later to present the various costs incurred in mixing feeds.

The basic factors to consider in selecting a batch mixer are: The methods of loading and unloading, physical characteristics of the ingredients mixed, the quality of mix desired, and cleanout characteristics. Important physical characteristics of the ingredients are shape, density, surface area, absorption and adsorption, cohesion, and electrical charge. These characteristics are affected by changes in moisture and temperature.

Two major types of batch mixers currently in use are the vertical and the horizontal types.

The vertical batch mixer was developed first. Many changes have been made in recent years to make this type more efficient. Capacities of these mixers range on the average from 1/4 ton to 3 tons. They can be loaded from either the top or the bottom. These mixers may be equipped with a single or double screw running vertically in the mixer chamber to move the material. Liquids can be introduced directly into vertical mixers, although this method has some shortcomings. When liquids are added to dry feeds, blending requires a longer mixing cycle to break up the balls formed during the mixing operations.

Vertical mixers have been used for years in the smaller plants producing custom mixed feeds. Many plants will probably continue to use this mixer because it is versatile, has a low initial cost, and is relatively inexpensive to operate and maintain.

Horizontal batch mixers have become increasingly popular in large plants. This type of mixer usually has opposing outer and inner ribbons mounted on a center drive shaft. Paddles often are located near the center of this assembly to provide additional mixing action near the core of the batch. The material is conveyed from side to side, end to end, and top to bottom of the mixing chamber. Discharge gates are located at either end or at the center. The material drops through these discharge gates into the conveying system or into a surge bin located beneath the mixer door. A surge (or storage) bin enables the mixer to be emptied rapidly. A new batch can be mixed while the surge bin is being emptied. The horizontal mixer is capable of blending in liquids up to 5 percent of total batch weight without the formation of "feed balls."

Batch mixing systems used by the mixed feed industry vary widely. Many of the small local feed mills use a manual system with a single platform scale to weigh each ingredient called for in the formula. Although there are several modifications of this system, all require much time until the various ingredients are weighed, dumped into the mixer, and thoroughly blended.

Some small mills have a weigh buggy to collect and weigh the individual ingredients. A weigh buggy is a large tank mounted on a platform scale on rollers. This buggy is placed under an ingredient bin, the desired amount of the ingredient is weighed into it, and the buggy is then rolled over to the mixer and dumped. This weigh buggy method of weighing is more efficient than the previous method of bagging and weighing the ingredients.

Semiautomatic

The semiautomatic batch system is more highly mechanized than the manual system but is operated manually with push buttons. Semiautomatic batch systems have a scale hopper mounted over a horizontal mixer. Most of the feed ingredients are located in overhead storage bins. An electric panel board with buttons controls the feeder screws that move the feed materials from the bins into the scale. A dial indicator is usually located on the floor next to the panel board so that the operator can read the weight of the various ingredients flowing into the scale hopper. Ingredients are accumulated one at a time. After all dry ingredients are in the hopper, they are dropped into the mixer. (Premixes usually are weighed separately and dumped into the mixer.) While one batch is being mixed, a new batch of ingredients is weighed in the scale hopper. Some modifications of this system are more automatic than others. The automatic features, of course, tend to reduce errors inherent in manual operation.

Automatic

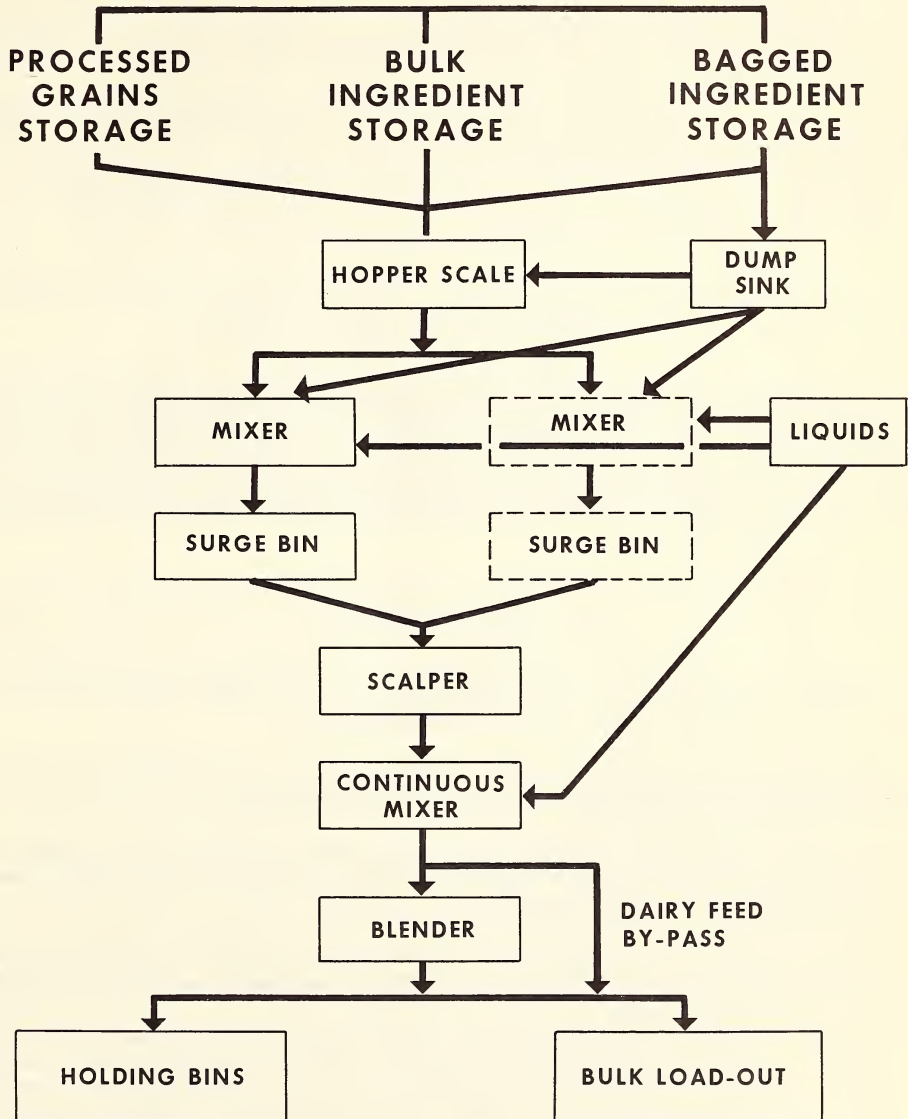
One important factor in any semiautomatic or fully automatic system is the material flow from the overhead bins. A uniform material flow must be maintained for an automatic system if it is to be efficient and accurate. In most systems, screw conveyors and feeders regulate the flow of materials from the storage bins.

The automatic system is basically the same as the semiautomatic system except that it requires little manual control of the flow of materials. The system is set up by the worker with weight selectors on the panel board or with some other method of proportioning the amount of each ingredient in the formula to be mixed. After the panel board is set according to formula, the system becomes fully automatic. Other methods, such as batch plug, formula capsule, and punch card, are used to make systems operate automatically.

Flow Diagram

The flow diagram in figure 1 outlines the mixing process and conforms to the mixing center definition. The mixing center begins where the various ingredients are stored in bins or bags. Ingredients of the batches are proportioned semiautomatically. Ingredients are moved from the bottom of each storage bin to the central weigh hopper by means of a feeder conveyor. An air-operated slide arrangement is provided between bin discharge and the conveyor.

FLOW DIAGRAM FOR MIXING CENTER



Equipment needed for the mixing center producing 80 tons of feed in 8 hours. Dotted lines show additional equipment for the 200-ton center.

Figure 1

The batch weigh hopper receives all of the dry ingredients. All microingredients or premixes are preweighed and manually dumped into the scale hopper or directly into the mixer. A central panel remotely controls the feeder conveyors under the supply bins and regulates the flow of ingredients. The panel controls may be equipped to operate either manually or automatically. Many occasions can arise where the manual operation is necessary. From the scale hopper the ingredients are dropped into a horizontal mixer. This mixer should be of the same capacity as the weigh hopper so that a uniform flow through the plant is possible. After the materials have been thoroughly mixed, the feed is dropped directly into a surge or storage bin under this mixer. The drop-bottom mixer has several advantages over the conventional horizontal type. The mixed feed can be dropped into a surge bin and the mixer can be made ready to mix another batch in a short time. Another advantage that is becoming increasingly important is the noncontamination feature. The drop-bottom mixer is self-cleaning, since there are no corners for drugs or other materials to accumulate and contaminate subsequent batches.

A drop-bottom mixer installation requires a surge bin below the mixer. This bin should hold a minimum of one batch. The scale hopper above the mixer and the surge bin below the mixer should provide an efficient operation.

From the surge bin, the mixed feed is conveyed at a uniform rate to a scalper which removes foreign material from the mixed feed. A continuous mixer is then used to blend liquids with the dry ingredients. A finished-feed blender following the continuous mixer tends to make the feed more uniform. This piece of equipment further mixes the materials and breaks up any lumps formed when liquids are applied in the mixing process. From the blender, the finished feeds are sent to the storage bins in other departments.

Operating Duties

Standards for production labor are estimates of production man-hours necessary to perform an operation or operations with a given plant and equipment, including allowances for personal time, delays, and maintenance.

Workers in the mixing center spend most of their time in this area. They typically perform the following duties in an 8-hour shift:

1. Weigh and mix the proper bulk ingredients listed on the formula sheet and add proper amounts of bagged ingredients that are to be added to each batch. In doing this the workers will:
 - a. Check the scale and other equipment before starting each batch.
 - b. Assemble all bagged ingredients, including premixes, listed on the formula sheet.
 - c. Compare the cumulative weight shown on the formula sheet after adding each ingredient, and compare the total weight of the batch with the formula sheet before emptying the scale. Several lots of material will be dumped into the hopper scale to make up the batch. After all bagged ingredients plus microingredients have been dumped, the batch is ready to be mixed.
2. Start, stop, and operate the mixer. The following steps usually are taken:
 - a. Check the flow of materials into and out of the mixer.

- b. Schedule the dumping of mixed feed into the surge bins, dumping of ingredients from hopper scale, and the preparation for another weighing of a new batch so that changeover time is kept to a minimum.
 - c. Check hopper scale, mixer, and surge bin before dumping so that contamination will be minimized.
 - d. Add liquids to mixed feed, as required on the formula sheet.
3. Operate the scalper and finished feed blender for a uniform product free of lumps, string, and other foreign matter.
4. Other duties required of the workers include:
 - a. Take quality control and other precautionary steps to assure production of a quality product.
 - b. Perform maintenance jobs as assigned.
 - c. Perform some housekeeping functions.

THE 80-TON MODEL CENTER

A semiautomatic batch feed mixing center with a capacity of 80 tons of mixed feed per 8-hour day has become popular in the feed industry because, despite its small size, it is fully adequate to serve the farmers in many areas. It has an annual volume of 20,800 tons of feed, assuming 260 operating days and 8 hours per day, or 41,600 tons annually with 2 shifts a day. A plant of this size requires only a modest capital investment and a small labor force, yet it can produce mixed feeds at moderate cost.

This model will mix 40 two-ton batches of feed with 14 formula changes in each 8-hour shift. Feed produced is 50 percent poultry feed, 30 percent cattle feed, and 20 percent hog feed.

Equipment

The total investment in new equipment for this model feed mixing center is estimated at \$49,131, including installation charges of 33 percent (table 2). ^{1/} The horizontal mixer with a capacity of 2 tons and complete with drop-bottom discharge gates and surge bin costs \$8,033, or about a sixth of the total equipment cost. The 16 feed conveyors cost \$13,440, or a little over 25 percent of the total equipment investment in this center. Other major equipment items are the fat system at \$6,135, the molasses system at \$4,438, a double-agitator continuous mixer with drop bottom at \$3,591, and a scale hopper complete with an air-operated gate at \$3,500. The investment of \$3,750 for a steam boiler, shown in table 2, does not cover the full cost of approximately \$26,000 for this important item. This estimate is the result of allocating to the mixing department a part of the plant's investment in the boiler system on the basis of the share of the steam used in the mixing center.

^{1/} Installation charges may vary from 20 to 40 percent of equipment cost. This range is influenced by the amount of (a) labor required, (b) electrical wiring, piping, and other materials necessary for proper installation, and (c) reinforcement of an existing structure or facility to support the weight of the equipment.

Table 2.--Quantity and approximate cost of equipment for model mixing center producing 80 tons of feed per 8-hour day

Equipment <u>1</u> /	Number	Approximate cost <u>2</u> /
Feeder conveyors.....	16	\$13,440
6" feeder screws.....	4	
9" feeder screws.....	6	
12" feeder screws.....	6	
Tank scale, complete with cabinet, 5,000 pound dial, tare beam, and recorder.....	1	2,973
Scale hopper, capacity 5,000 pounds, complete with air-operated discharge gate.....	1	3,500
Semiautomatic control console, complete with feeder conveyor controls, etc.	1	1,160
Horizontal mixer, 2-ton capacity, with air operated discharge gate, 2-ton capacity surge bin.....	1	8,033
Finished feed scalper, 15-ton per hour capacity.....	1	1,751
Magnetic separator, 14" spout magnets.....	1	360
Continuous mixer, double agitator, drop bottom.....	1	3,591
Liquid systems:		
Fat system, capacity 40 pounds per minute.....	1	6,135
Molasses system, capacity 12 gallons per minute.....	1	4,438
Boiler (steam) <u>3</u> /.....	--	3,750
Total.....	--	49,131

1/ Each item of equipment listed is complete with all accessories and parts (except elevators and conveyors) necessary for complete installation.

2/ Includes estimated installation charge of 33 percent; some pieces of equipment require a higher or a lower installation charge.

3/ Prorated on basis of percentage of plant's steam needed to heat liquids for mixing operation. The original cost of the boiler including installation is assumed to be \$26,000.

Operating Costs

Labor

Direct production labor requirements for this model mixing center are 10.16 man-hours per 8-hour shift (table 3). The center requires one worker full time and another less than one-fourth time. The second worker divides his day between the mixing center and other departments in the feed mill. In addition, the plant foreman, or supervisor, spends about an hour a day in the mixing center. With a 2-shift operation of 16 hours a day, total labor requirements are doubled.

With an assumed average hourly wage of \$1.82 for direct labor, annual labor costs are \$4,808 for a one-shift operation plus \$650 for supervisory labor. For a two-shift operation total labor costs are more than doubled -- \$9,880 for direct labor and \$1,326 for supervision -- because of the necessity to pay somewhat higher wages for the second crew. In this study, the assumed average wages for direct labor for the second shift are \$1.92 an hour and supervision expense is \$676 a year.

Power Costs

Electricity necessary to operate the 80-ton model mixing center costs an estimated \$2,075 a year for a single-shift operation and \$4,150 for a two-shift plant (table 4). An average power rate of 3.25 cents per kilowatt hour is assumed. ^{2/} The horizontal mixer is the largest user of electric power in the center, requiring more than 50 percent of the total for the center.

Depreciation

The estimated annual depreciation of the equipment in the model mixing center is \$3,262 (table 5). This estimate is based on the straight-line method of computation, a 15-year useful life for most of the items (with the exceptions shown in table 5), and zero scrap value at the end of the assumed life period. Thus, the depreciation rates used in this study are consistent with suggestions of the Internal Revenue Service. ^{3/} The assumed zero scrap value, however, may overstate annual depreciation charges slightly.

Although a case may be made for somewhat higher depreciation charges for plants operating more than one shift a day, the same total charges are assumed in this study regardless of annual hours of operation. Depreciation resulting solely from additional hours of operation seems likely to be small in relation to time depreciation and obsolescence, particularly if a plant carries on an adequate program of equipment maintenance.

No allocation of depreciation on the feed plant building is made in this study to the mixing center. Building depreciation varies with the type of structure, geographic location, design, and other factors that make it difficult to allocate a reasonable amount.

^{2/} Vosloh, Carl J., Jr., and Askew, W. E. Custom Feed Milling in the Midwest, U. S. Dept. Agr. Mktg. Res. Rpt. 273. Sept. 1958.

^{3/} U. S. Internal Revenue Service. Tables of Useful Lives of Depreciation Property Bulletin "F" Internal Revenue Service Publication 173, 66 pp., 1955.

Table 3.--Estimated labor requirements for mixing center producing 80 tons of feed in one shift and 160 tons of feed in two shifts per day 1/

Job	Labor standard (man-hours)	Quantity in one shift	Man-hours		Man-hours per ton
			1 shift	2 shifts	
Move ingredients with handtruck <u>2/</u>	0.166 per ton	12 tons	1.992	3.984	
Open bags <u>2/</u>	.066 per ton	12 tons	.792	1.584	
Dump bags <u>2/</u>	.050 per ton	12 tons	.600	1.200	
Weigh bulk ingredients <u>3/</u> ..	.033 per batch	40 batches	1.320	2.640	
Starting machines.....	.2 per day	1 time	.2	.4	
Clean up.....	.060 per batch	40 batches	2.400	4.800	
Change formula.....	.083 per change	14 changes	1.162	2.324	
Allowance <u>4/</u>			1.694	3.388	
Total production labor..			10.160	20.320	0.127
Supervision.....			1.00	2.00	0.013
Total labor.....			11.160	22.320	0.140

1/ Eight hours worked per shift.

2/ Includes premixes.

3/ Includes liquids.

4/ 20 percent of time allowed for worker's personal requirements.

Table 4.--Annual electric power requirements and costs for model mixing center producing 80 tons of feed in one shift

Equipment, and manufacturer's rating of motor	Motors	Total adjusted horsepower $\frac{1}{2}$	Motor operations		Electric power, per year	
			per shift		Cost $\frac{3}{4}$	
			Times	Time	Use $\frac{2}{2}$	1 shift : 2 shifts 4/
	Number	Horsepower	Number	Hours	Kw.-hr.	Dollars
Feed conveyors, 3/4-horsepower motor.	16	14.12	40	2.4	6,518.20	212 424
Horizontal mixer, 20-horsepower motor.	1	23.53	2	8.0	36,511.80	1,187 2,374
Feed scalper, 1/2-horsepower motor.	1	.59	2	8.0	915.20	30 60
Continuous mixer: 10-horsepower motor.	1	11.76	2	2.4	5,473.10	178 356
1-horsepower motor.	1	1.18	2	2.4	549.17	18 36
Fat system: 3-horsepower motor.	1	3.53	1	8.0	5,478.20	178 356
2-horsepower motor.	1	2.35	2	4.0	1,822.60	59 118
Molasses system: 3-horsepower motor.	1	3.53	1	8.0	5,478.20	178 356
2-horsepower motor.	1	2.35	2	2.4	1,094.60	35 70
Total.....	--	62.94	--	--	63,841.07	2,075 4,150

$\frac{1}{2}$ Electric motors under 100 hp. must be adjusted for average efficiency by use of 0.85 conversion factor.

$\frac{2}{4}$ Kilowatt-hours (kw.-hr.) = Number of hours operating per day x adjusted horsepower x kw.-hr. conversion factor (.746) x number of operating days (260).

$\frac{3}{4}$ Average cost per kw.-hr. used was 3.25 cents (used in a previous study, Vosloh, Carl J., Askew, W. R., and Brensike, V. J. Custom Feed Milling in the Midwest. U. S. Dept. Agr. Mktg. Res. Rpt. 273, 23 pp. Sept. 1958).

$\frac{4}{4}$ Single-shift cost is doubled for two-shift operation.

Table 5.--Annual depreciation for equipment in model mixing center producing 80 tons of feed per 8-hour day

Equipment	Average life	Approximate cost	Annual depreciation
	Years	Dollars	Dollars
Feeder conveyors.....	15	13,440	896
Tank scale.....	15	2,973	198
Scale hopper.....	15	3,500	233
Semiautomatic control console.....	10	1,160	116
Horizontal mixer.....	15	8,033	536
Finished feed scalper.....	15	1,751	117
Magnetic separator.....	15	360	34
Continuous mixer.....	15	3,591	239
Fat system.....	15	6,135	409
Molasses system.....	15	4,438	296
Boiler.....	20	3,750	188
Total.....	--	49,131	3,262

Interest

The allowance for interest on the investment in the equipment in the center is \$1,474 (table 6). This is an imputed cost which takes no account of the source of investment capital. Although business firms usually show interest as an expense only if paid to outside agencies, the true capital cost includes an interest allowance on the owner's equity, too. The estimate of \$1,474 is based on the assumed rate of 6 percent and an average investment in equipment equal to half of the original investment of \$49,131.

Fuel

Fuel used by the boiler is estimated to be \$1,040 for one shift and double this amount if the plant operates two shifts (table 6). Allocation of fuel cost is based on the amount of steam used in this center in relation to the total required in all plant operations.

Maintenance

The annual labor cost of a fully adequate program for maintenance of equipment in the 80-ton model mixing center is estimated at \$3,393 for a plant operating one 8-hour shift a day and \$6,937 for a two-shift operation, (table 6). This estimate is based on 5.8 hours of machinery maintenance labor for each daily shift and wage rates of \$2.25 for the first shift and \$2.35 for the second shift. Although these estimates for maintenance labor time and cost may seem somewhat high, they may be justified on at least two grounds. Skilled electricians and mechanics are needed in modern feed mills to service the complex electrical controls and other machinery. A fully adequate program of preventive maintenance can prevent costly plant shutdowns and

Table 6.--Total annual operating costs in model mixing center producing 80 tons of feed per shift 1/

Cost item	1 shift (20,800 tons per year)		2 shifts (41,600 tons per year)	
	Total cost	Percent of total	Total cost	Percent of total
	<u>Dollars</u>	<u>Percent</u>	<u>Dollars</u>	<u>Percent</u>
Labor				
Production <u>2/</u>	4,808	29	9,880	34
Supervision <u>3/</u>	650	4	1,326	5
Depreciation on equipment.....	3,262	20	3,262	11
Interest on investment.....	1,474	9	1,474	5
Electricity.....	2,075	12	4,150	14
Fuel (steam).....	1,040	6	2,080	7
Maintenance <u>4/</u>	3,393	20	6,937	24
Total.....	16,702	100	29,109	100

1/ Costs are calculated using 8 hours per shift and 260 days per year.

2/ BLS, Earnings for Paid Workers in Animal Feeds Industry. A differential of 10 cents per hour for night shift workers is added to the industry average of \$1.82.

3/ Foreman's estimated wage rate is \$2.50 per hour day shift, \$2.60 per hour night shift.

4/ Labor cost alone; excludes cost of replacement parts and maintenance supplies. Maintenance employees' time estimated in relation to equipment cost. (5.8 man-hours per shift based on in-plant cost standards established by the Feed Production School of 1956.) Estimated rate is \$2.25 per hour day shift, \$2.35 per hour night shift.

can extend the useful life of valuable equipment. No estimate of costs of repair parts and maintenance supplies is made. These vary from plant to plant so much that a useful standard cannot be established with data presently available.

THE 200-TON MODEL CENTER

Many sizes of feed mills are being constructed by the feed industry. Some of these have mixing centers similar to the model which has a capacity of 200 tons of feed mixed per 8-hour day. If the plant operates 260 days a year it has an annual volume of 52,000 tons of mixed feeds with one 8-hour shift per day, or 102,000 tons with two shifts a day.

This model will mix 100 2-ton batches of feed with 14 formula changes in each 8-hour shift. Production is 50 percent poultry feed, 30 percent cattle feed, and 20 percent hog feed.

Equipment

The total investment in new equipment, including installation charges of 33 percent, for this model feed mixing center is estimated at \$79,858 (table 7). Two horizontal mixers with a capacity of 2 tons each, complete with drop-bottom discharge gates and surge bins, cost \$18,107 or about 23 percent of the total cost of equipment. Twenty feeder conveyors cost about \$16,000 or 20 percent of the equipment investment in this model.

Costs of other major pieces of equipment in the model are \$9,968 for the batch system (tank scale, scale hopper, and control console), \$8,151 for the fat system, \$6,449 for the molasses system, and \$3,680 for the fish-oil system. Boiler cost of \$4,650 is an estimate based on the share of the plant's steam used in the mixing center.

Operating Costs

Labor

Production labor requirements for this model center are 16,315 man-hours per 8-hour shift (table 8). This center requires at least one full-time mixer operator and two part-time helpers. The helpers divide their time between the mixing operation and the other departments in the feed mill. The mill supervisor or foreman spends about 2 hours per 8-hour shift in the mixing center. With a 2-shift operation of 16 hours per day, total labor requirements are doubled.

With an assumed average hourly wage rate of \$1.82 for production labor, the annual costs are \$7,720 for a single shift operation plus \$1,300 for supervisory labor. Labor costs for a 2-shift operation are more than doubled -- \$15,865 for production labor and \$2,652 for supervision -- because of the need to pay higher wages for the night workers. In this study, the assumed average hourly wage rate is \$1.92 for night workers and \$2.60 for the night supervisor.

Power costs

Annual cost of electricity for operating the 200-ton model is estimated to be \$6,871 for a single shift operation or \$13,742 for a two-shift plant (table 9). An assumed average power rate of 3.25 cents per kilowatt hour is used in these computations. The two horizontal mixers use about 40 percent of the total power in this model center.

Depreciation

Estimated annual depreciation of the equipment in the model center is \$5,317 (table 10). This computation is based on the straight-line method. A useful life of 15 years is assumed for most of the equipment shown in table 10 with zero scrap value at the end of the life period. Depreciation rates used in this research are consistent with the suggested rates published by the Internal Revenue Service. Annual depreciation charges may be overstated slightly when a zero scrap value is used.

The same total depreciation charges are assumed in this study regardless of the annual hours of operation. It is possible for a plant operating more than one shift to have a higher depreciation charge. It seems that less depreciation is from additional

Table 7.--Quantity and approximate cost of equipment for model mixing center producing 200 tons of feed per 8-hour day

Equipment <u>1/</u>	Number	Approximate cost <u>2/</u>
Feeder conveyors.....	20	\$16,000
6" feeder screws.....	6	
9" feeder screws.....	7	
12" feeder screws.....	7	
Tank scale, complete with cabinet, 5,000 pound maximum, with tare beam, recorder.....	1	4,375
Scale hopper, capacity 5,000 pounds, complete with air-operated discharge gate.....	1	3,500
Semiautomatic control console, complete with feeder conveyor controls, etc.	1	2,093
Horizontal mixers, 2-ton capacity, each with air-operated discharge gates, 2-ton capacity surge bin...	2	18,107
Finished feed scalper, 30-ton per hour capacity.....	1	3,500
Magnetic separator, drum type.....	1	1,680
Continuous mixer, double agitator, drop bottom, feeder for regulating flow.....	1	4,740
Liquid systems:		
Fat system, capacity 40 pounds per minute.....	1	8,151
Molasses system, capacity 12 gallons per minute.....	1	6,449
Fish-oil system, capacity 40 pounds per minute.....	1	3,680
Feed dresser, hammer mill 14 inch	1	2,933
Boiler (steam) <u>3/</u>	--	4,650
Total.....		79,858

1/ Each item of equipment listed is complete with all accessories and parts (except elevators and conveyors) necessary for complete installation.

2/ Includes estimated installation charge of 33 percent; some pieces of equipment require a higher or a lower installation charge.

3/ Prorated on basis of percentage of plant's steam used to heat liquids for mixing operation. The original cost of the boiler including installation is assumed to be \$30,000.

Table 8.--Estimated labor requirements for mixing center producing 200 tons of feed in one shift and 400 tons of feed in two shifts per day ^{1/}

Job	Labor standard (man-hours)	Quantity in one shift	Man-hours per day		Man-hours per ton
			1 shift	2 shifts	
Move ingredients with forklift <u>2/</u>	0.083 per ton	30 tons	2.490	4.980	
Open bags <u>2/</u>	.066 per ton	30 tons	1.980	3.960	
Dump bags <u>2/</u>	.050 per ton	30 tons	1.500	3.000	
Weigh bulk ingredients <u>3/</u> ..	.025 per batch	100 batches	2.500	5.000	
Starting machines.....	.2 per day	1 time	.200	.400	
Clean up.....	.050 per batch	100 batches	5.000	10.000	
Change formula.....	.083 per change	14 changes	1.162	2.324	
Allowance <u>4/</u>			1.483	2.966	
Total production labor..			16.315	32.630	0.082
Supervision.....			2.000	4.000	0.010
Total labor.....			18.315	36.630	.092

^{1/} Eight hours worked per shift.

^{2/} Includes premixes.

^{3/} Includes liquids.

^{4/} 10 percent of time allowed for worker's personal requirements.

Table 9.--Annual electric power requirements and costs for model mixing center producing 200 tons of feed in one shift

Equipment, and manufacturer's rating of motor	Motors	Total adjusted horsepower <u>1</u> /	Motor operations per shift	Electric power, per year		
				Cost <u>3</u> /		
				Use <u>2</u> /	1 shift : 2 shifts	4/
			Times : turned on : required :	Hours	Dollars	Dollars
Feeder conveyors, 3/4-horsepower motor.....	20	17.65	100	6.51	22,287.20	725 1,450
Horizontal mixers:						
20-horsepower motor.....	2	47.06	2	8	73,021.00	2,373 4,746
5-horsepower motor.....	2	11.76	2	8	18,246.80	593 1,186
Scalper, 1-horsepower motor.....	1	1.18	2	8	1,830.40	59 118
Continuous mixer:						
25-horsepower motor.....	1	29.41	2	8	45,635.20	1,483 2,966
1-horsepower motor.....	1	1.18	2	8	1,830.40	59 118
Liquid systems:						
Fat:						
3-horsepower motor.....	1	3.53	1	8	5,478.20	178 356
2-horsepower motor.....	1	2.35	2	4	1,822.60	59 118
Molasses:						
3-horsepower motor.....	1	3.53	1	8	5,478.20	178 356
2-horsepower motor.....	1	2.35	2	2.4	1,094.60	36 72
Fish solubles:						
3-horsepower motor.....	1	3.53	1	8	5,478.20	178 356
2-horsepower motor.....	1	2.35	2	4	1,822.60	59 118
Feed dresser, 30-horsepower motor.....	1	35.29	2	4	27,380.60	891 1,782
Total.....	--	161.17	--	--	211,406.00	6,871 13,742

1/ Electric motors under 100 hp. must be adjusted for average efficiency by use of 0.85 conversion factor.

2/ Kilowatt-hours (kw.-hr.): Number of hours operating per day x adjusted horsepower x kw.-hr. conversion factor (.746) x number of operating days (260).

3/ Average cost per kw.-hr. used was 3.25 cents (used in a previous study, Vosloh, Carl J., Askew, W. R., and Brensike, V. J. Custom Feed Milling in the Midwest. U. S. Dept. Agr. Mktg. Res. Rpt. 273, 23 pp. Sept. 1958.

4/ Single-shift cost is doubled for two-shift operation.

Table 10.--Annual depreciation for equipment in model mixing center producing 200 tons of feed per 8-hour day

Equipment	Average life	Approximate cost	Annual depreciation
	<u>Years</u>	<u>Dollars</u>	<u>Dollars</u>
Feeder conveyors.....	15	16,000	1,067
Tank scale.....	15	4,375	292
Scale hopper.....	15	3,500	233
Semiautomatic control console.....	10	2,093	209
Horizontal mixers.....	15	18,107	1,207
Finished feed scalper.....	15	3,500	233
Magnetic separator.....	15	1,680	112
Continuous mixer.....	15	4,740	316
Fat system.....	15	8,151	543
Molasses system.....	15	6,449	430
Fish oil system.....	15	3,680	245
Feed dresser.....	15	2,933	197
Boiler (steam).....	20	4,650	233
Total.....	--	79,858	5,317

wear from a second shift in relation to the time depreciation and obsolescence. This is especially true if a plant carries out a preventive maintenance program as do many in the feed industry.

Building depreciation is not included in this model's costs. The variation in building depreciation is great and is influenced by many factors.

Interest

Interest on the equipment investment in this center is \$2,396 (table 11). This cost is assumed to exist whether funds for the investment are borrowed or are those of the owner. Business firms show interest as an expense only if paid to outside agencies, but the true capital cost includes the interest on the owner's equity. The estimated interest of \$2,396 is based on the assumed interest rate of 6 percent for the average investment in equipment equal to half the original investment of \$79,858. Interest on building space for this center is not included.

Fuel

This center will use about \$2,600 in fuel to heat the liquids used during one shift (table 11). If the plant operates 16 hours per day, the fuel cost will be doubled. Allocation of fuel cost is based on the amount of steam used in the mixing center in relation to the total used by the plant.

Table 11.--Total annual operating costs in model mixing center producing 200 tons of feed per shift 1/

Cost item	1 shift (52,000 tons per year)		2 shifts (104,000 tons per year)	
	Total cost	Percent of total	Total cost	Percent of total
	<u>Dollars</u>	<u>Percent</u>	<u>Dollars</u>	<u>Percent</u>
Labor				
Production 2/.....	7,720	24	15,865	27
Supervision 3/.....	1,300	4	2,652	4
Depreciation on equipment.....	5,317	16	5,317	10
Interest on in- vestment.....	2,396	7	2,396	4
Electricity.....	6,871	21	13,742	23
Fuel (steam).....	2,600	8	5,200	9
Maintenance 4/.....	6,552	20	13,395	23
Total.....	32,756	100	58,567	100

1/ Costs are calculated using 8 hours per shift for 260 days per year.

2/ BLS, Earnings for Paid Workers in Animal Feeds Industry. A differential of 10 cents per hour for night shift workers is added to the industry average of \$1.82.

3/ Foreman's estimated wage rate is \$2.50 per hour day shift, \$2.60 per hour night shift.

4/ Labor cost alone; excludes cost of replacement parts and maintenance supplies. Maintenance employees' time estimated in relation to equipment cost. (11.2 man-hours per shift based on in-plant cost standards established by the Feed Production School of 1956.) Estimated rate of \$2.25 per hour day shift, \$2.35 per hour night shift.

Maintenance

Annual labor cost for maintenance of equipment in the mixing operation is estimated to be about \$6,552 for a one-shift production schedule or \$13,395 for 2 shifts (table 11). This estimate is based on 11.2 man-hours for each 8-hour shift. An assumed average wage rate of \$2.25 is used for the single shift and \$2.35 for the second shift. These estimates may seem high, but they can be justified. A preventive maintenance program is an important factor in keeping repair costs low. A suitable program can prevent many serious shutdowns and extend the useful life of the equipment. Cost of repair parts and maintenance supplies are not estimated because they vary greatly from plant to plant.

AUTOMATIC WEIGHING EQUIPMENT

Although both of the models in this report were developed with semiautomatic batching and weighing equipment, fully automatic equipment is available for plants of these sizes. Automatic equipment has the advantage of reducing labor requirements and of reducing the number and probable costs of human errors in mixing feeds.

Formula feeds usually contain many ingredients, including minute quantities of some important nutrients, and the cost of errors in mixing, although difficult to estimate, can be high. This is especially true of errors that produce dissatisfaction among a plant's customers.

Nevertheless, a partial answer to the question of the relationship between costs and benefits of automatic versus semiautomatic batching and weighing equipment can be developed to assist plant managers and owners in choosing between the two systems. For the 80-ton model center the semiautomatic equipment costs \$4,133 (table 12); an automatic system for this center could cost \$12,000 or more. The difference between annual capital charges (depreciation, interest, and maintenance) for the two systems is about \$1,060. This is equal to 5.1 cents a ton if the plant operates only one shift a day and about 2.6 cents a ton for a two-shift operation.

To offset fully these higher equipment costs in the 80-ton model, with the wage rates assumed in this study, total labor requirements must be reduced from 10.16 hours per 8-hour shift to 7.87 hours, or about 22 percent. In other words, batch time must be reduced 3.4 minutes (table 13). Such an increase in labor efficiency seems unlikely to result from the use of the automatic equipment. Thus, for the plant operating only one shift a day, an investment in this automatic equipment probably would not be profitable unless its wage rate for direct production labor is substantially higher than the \$1.82 an hour assumed in this study.

On the other hand, the automatic equipment might be a profitable investment for the 80-ton plant operating two or more shifts a day. The additional capital charges probably can be offset, because the needed reduction in labor requirements is relatively smaller -- from 20.32 hours to 17.87 hours -- for a two-shift operation, or about 12 percent. Such an improvement in labor efficiency seems feasible. The automatic equipment reduces the time required for the mixer operator to handle his principal duties so that he may perform some of the operations usually done by the part-time helper.

Similar conclusions seem valid for the larger 200-ton mixing center (tables 12 and 13). That is, unless the feed plant operates two or more shifts a day, the additional capital charges for the automatic batching and weighing equipment probably cannot be offset by gains in labor efficiency, with the wage rates assumed in this study. However, if wage rates rise or if the difference in the costs of the two systems should narrow, the automatic system will become profitable for both models at lower annual outputs.

Finally, an investment in the automatic equipment may be a profitable venture if it reduces the number of errors the plant makes in mixing feeds. The resulting improvements in customer satisfaction ought to have a favorable impact on a plant's sales volume, a factor best left to each plant manager to estimate for himself.

IMPLICATIONS OF FINDINGS FOR MANAGEMENT DECISION

Management is the deciding force in allocating the factors of production. With the proper allocation of labor, machines, and money, management can build and operate an efficient plant. Thorough planning of the plant and equipment for the desired volume of production is essential in order to maintain a uniform flow of material in the plant. Management should know plant performance and be aware of the necessity for plant remodeling or machine replacement.

Table 12.--Equipment costs and labor requirements for automatic and semiautomatic equipment in mixing department of 2 models of feed mill

Production per 8-hour shift, and type of equipment	Equipment cost		Labor per ton		Total labor	
	:		:		:	
	Annual 1/ Per ton		1 shift : 2 shifts : 1 shift : 2 shifts		:	
Original :	Total :	Per ton	1 shift :	2 shifts :	1 shift :	2 shifts
:	:	:	:	:	:	:
:	Dollars	Cents	Man-hours	Man-hours	Man-hours	Man-hours
80-ton model: 2/ :						
Automatic..... :	12,000	7.02	3.51	0.0984	0.1117	7.87
Semiautomatic... :	4,133	1.92	.96	.1270	.1270	10.16
Difference.... :	7,867	5.10	2.55	.0286	.0153	2.29
200-ton model: 3/ :						
Automatic..... :	16,000	3.74	1.87	.0398	.0476	7.960
Semiautomatic... :	6,468	1.20	.60	.0587	.0587	11.746
Difference.... :	9,532	2.54	1.27	.0189	.0111	3.786
						4.452

1/ Includes depreciation, interest, and maintenance for higher priced equipment.

2/ Annual production: 1 shift 20,800 tons, 2 shifts 41,600 tons.

3/ Annual production: 1 shift 52,000 tons, 2 shifts 104,000 tons.

Table 13.--Time that must be saved per batch to justify added cost of automatic over semiautomatic feed mixing equipment

Production per 8-hour day	:	1 shift	:	2 shifts
	:		:	
	:	<u>Minutes</u>	:	<u>Minutes</u>
	:		:	
80-ton model.....	:	3.4	:	1.8
200-ton model.....	:	2.27	:	1.33

Management has discovered that some smaller plants in certain areas can operate as cheaply as the larger ones despite economies of scale. Management has to answer such questions as: whether a feed plant should be built to produce the needed volume in one or more than one shift or if an established plant could economically increase its volume with an increase in the number of shifts. Many factors affect the cost per ton for a given plant. Reduction in production expenses per ton does not follow automatically as plant production increases. The entire mill's operation has to be analyzed, from the procuring of raw materials through processing to the final sale of the finished product. A lower per-ton cost of production would not warrant increasing the plant output if higher costs of selling the finished product offset the savings in production costs.

Established Plants

Management operating an established feed plant is confronted with many questions. Although the alternatives for decisions are frequently limited, the final answer to such questions must be in terms of lowering the operating costs per unit. Reduction of the cost per ton can be accomplished basically by utilizing plant capacity more fully.

Managements' choice between one and two shifts for an established plant is often limited by the available markets for mixed feeds. Table 14 demonstrates that it is preferable to operate a plant with two shifts during the year. Considerable savings are achieved by utilizing plant facilities more fully.

If the plant can sell a larger volume of feed, a change from one shift to two shifts per day in a plant could reduce per unit costs considerably. In the smaller 80-ton model, doubling the annual output by operating two shifts reduces the total operating costs from 80 to 70 cents per ton or about 12 percent (table 14). The economies achieved by the larger 200-ton model, operating two shifts and doubling the output, reduce the per-ton costs from 63 to 55 cents per ton or about 13 percent.

Fixed costs -- depreciation and interest on investment -- offer the main opportunity for reducing the unit cost in both models. Other cost items do not seem to be materially affected by the method used to develop the costs in the model plants. For example, it is possible that management can obtain a lower electricity rate when the quantity used is doubled.

Table 14.--Specified costs per ton for mixing feed with semiautomatic equipment, by size of annual production, 1 and 2 shifts

Cost items	Small plant		Large plant	
	20,800 tons (1 shift)	41,600 tons (2 shifts)	52,000 tons (1 shift)	104,000 tons (2 shifts)
	Cents per ton	Cents per ton	Cents per ton	Cents per ton
Labor:				
Production.....	23	24	15	15
Supervisory....	3	3	2	2
Equipment				
depreciation....	16	8	10	5
Interest on in-				
vestment.....	7	4	5	2
Electricity.....	10	10	13	13
Maintenance				
labor.....	16	16	13	13
Fuel (steam).....	5	5	5	5
Total.....	80	70	63	55

Building New Plants

Building new plant facilities raises further questions. Management has a fairly accurate estimate of the amount of feed that can be sold in a given area. If management determines that a given area has a potential annual sales volume of 40,000 to 50,000 tons of mixed feeds, the question arises: Should a large plant be constructed and operated with a single 8-hour shift or should a smaller plant be constructed and operated with more than one shift? On the basis of the model plants established in this report, an annual volume of 40,000 to 50,000 tons can be achieved by either the larger or the smaller plant.

Table 15 indicates that a larger plant with one shift per day might be preferable. It can produce the equivalent annual feed volume of 40,000 to 50,000 tons about 7 cents per ton less than the smaller plant with two shifts, or about 10 percent cheaper. The difference is greater for 2 1/2 shifts in the smaller plant, because of the high overtime labor costs. The smaller plants' costs are about 12 percent higher than costs incurred in the larger plant operating one shift 260 days a year. Although fixed costs in a larger plant are higher, the lower labor cost per unit produced in this plant would more than offset the higher fixed costs.

Apart from its lower per-unit operating costs, a larger feed plant might have an additional advantage. It would permit management to plan a long-range program of gradually increasing feeds sales from this plant. Additional production would require an increase in number of shifts and would tend to lower the per unit costs even more.

Earlier studies have indicated the trend toward decentralization and smaller feed plants. These trends have resulted primarily from: (1) increased demands for

Table 15.--Total cost per ton for mixing feed with semiautomatic equipment, by size of output and hours of operation 1/

Operation per day	Small plant		Large plant	
	Annual output	Cost per ton	Annual output	Cost per ton
	<u>Tons</u>	<u>Cents</u>	<u>Tons</u>	<u>Cents</u>
8 hours...	20,800	80	52,000	63
12 hours...	31,200	80	78,000	63
16 hours...	41,600	70	104,000	55
20 hours...	52,000	72	130,000	58

1/ Costs for less than a complete shift have been assumed on a straight basis except for labor cost. Overtime rates have been taken into account in calculating labor cost for both 12 and 20 hours of operation.

feed in certain areas, (2) demand for services and service competition, (3) small advantages in transportation costs, and (4) industry cost curve tends to level out once an annual volume of about 30,000 tons of feed is achieved. It was also apparent that most of the economies of scale were possible in the grinding, mixing, pelleting and packing cost centers. Smaller plants seem to be about as efficient in receiving, warehousing, and maintenance centers.

Since the mixing costs are the only costs considered in this study, these conclusions must be considered as only one part of the cost picture for a feed plant. Available capital for building will determine the size of mill a company will build only after the sales area and sales potential has been established.

The cost data presented in this study should be used only as a yardstick to combine with other cost data for the entire mill. No hard and fast decision on what is best for all situations is possible.

APPENDIX

Two important operations in the manufacture of formula feeds are premixing of micro-ingredients and the application of liquids to mixed feeds. Although these operations are not a part of all feed mixing plants, they are included in the appendix to emphasize some of the problems incurred in these phases of feed production.

Premix Preparation

The premixing of micro-ingredients is a precision operation. The equipment and procedures require a sound knowledge of the characteristics of all individual ingredients used in premixing. One mixer is usually insufficient for the manufacture of a number of complex premixes that have a wide variety of ingredients.

Care must be given to each phase of the premixing operation, with special emphasis on the actual blending process. Manufacturers want to produce a quality product, but there are many problems in blending the many potent ingredients.

Purchased Premixes vs. In-plant Mixing

If the commercial feed manufacturer makes his own premix, then he takes the responsibility for stability of micro-ingredients involved, proper distribution of materials through premix, quality control, and other factors. These are problems weighed by the feed manufacturer in deciding whether or not to manufacture his own premix. The additives used in premixes include vitamins, minerals, antibiotics, drugs, antioxidants, amino acids, and other micro-ingredients. New and more potent additives are being offered for marketing every day. Premixing is one of the most important problems confronting the feed mixing industry.

The use of micro-ingredients in poultry feeds assumes increasing importance. Proper and efficient handling of these highly potent additives in the feed manufacturing operation can only be accomplished through premixing. Premixing has become very specialized because of the nature of the products involved.

Some of the reasons for delegating the manufacturing of premixes are that the premix supply industry is better equipped to do the job and has greater accuracy in mixing and stronger quality control. However, many feed manufacturers have demonstrated that they can develop the necessary qualifications, and since in-plant premixing may be more versatile and often more economical, no hard and fast rule can be laid down as to which approach is more effective.

Premixing Equipment

Manufacturing a premix requires thorough blending of the active ingredients with the carrier. The major types of mixers used for premixing include the horizontal ribbon, the rotary batch, the twin shell, the double cone, and others. Each has advantages and disadvantages.

Premixing practices should be standardized to reduce error to the minimum. Competent personnel, accurate and sensitive scales, laboratory mixing of potent micro-ingredients, and prevention of static electricity contribute to efficient preparation of a good quality premix.

Purchased premixes are easier for the custom mixers to handle because many are packaged in a size which permits the use of a standard unit in a single batch. Large modern plants tend to purchase premixes of higher concentration in bulk, and small amounts are used in preparing the premixes used in the manufacture of feeds.

The final decision will be determined most of the time by the actual cost. In-plant premixing should pay its own costs. These costs should include all production costs of premixing, laboratory facilities necessary for adequate quality control, and amortization of additional equipment to sufficiently handle the premixing.

Use of Liquids

Feed mixing requires the blending of liquids with dry materials as well as mixing a number of dry materials together. New problems have risen with liquid mixing which are not present with the combining of dry material. These problems are found in storing, conveying, and proportioning the liquids, and in the actual mixing process. Fats and oils, fish solubles, and molasses are three of the most important liquids used by the mixed feeds industry. There are numerous other liquids such as those containing micro-ingredients which have created a greater necessity for careful handling of these materials.

Liquid storage facilities must meet certain requirements. Large storage tanks are made of carbon or stainless steel because the liquids stored are corrosive. Copper, brass, and bronze should not be used in any part of the liquid handling systems. The presence of free moisture in acid-bearing liquids greatly accelerates corrosion, even in steel tanks. For this reason storage tanks should have a sloping bottom with a water drain at the lowest point. Many feed manufacturers use two storage tanks for most liquids so that the tanks can be given a thorough cleanout periodically.

Liquids in storage must be heated. Molasses and fish solubles should be maintained at about 80°F. and fats at 120°. Before they are used all liquids are heated to a higher temperature, usually by steam or hot water coils in the large storage tanks. Agitators assist in the heating process. Agitators not only effect a more uniform heat transfer but also prevent the separation of constituents in these liquids.

The installation of liquid systems, particularly for fat and fish solubles, requires special consideration. Certain sizes of pipes, specially designed pumps, and special noncorrosive materials are some of the more important factors. Transfer lines from storage tanks to mixers should be insulated to keep liquids at the desired temperature.

Typical Liquid Flow

The flow pattern for fats and molasses requires similar in-plant piping systems. Main difference between the two systems is that the molasses system requires a current-use tank and the fat system requires a heat exchanger.

Liquids are usually strained before they enter the pump. The necessity to clean the strainers is usually indicated by a drop in pressure on the gauges. Most systems are equipped with a bypass so that the strainers may be cleaned from time to time.

All condensate from the heat exchanger should be emptied into a drain. Condensate could be returned to the boiler, but this is seldom done. Draining off the condensate is good insurance against damage to the boiler since it eliminates the possibility of fat leaking into the heat coils and being returned to the boiler.

Overflow of fat not being used is introduced back into the flow system at the pump. Fats are heated to a relatively high temperature before application to feeds and should not be returned to storage tanks. Fats heated to high temperatures over a period of time are damaged nutritionally.

In most systems, the liquids bypass the metering and control parts. This enables maintenance personnel to repair control parts while the system is in use. Air release valves are located before the meter. Care should be taken not to measure trapped air instead of the liquid.

Some molasses systems are constructed so molasses can be introduced into the mixer and the pellet mill at the same time. This requires separate pumping controls and other metering equipment for the mixer and the mill. A system of this type would be found in mills where feeds with a high percentage of molasses are produced.

Each plant may require a slightly different arrangement of equipment and installation, but the basic systems are the same. In systems that require manual proportioning, close control of the liquid added is more difficult than in the automatic systems.

Equipment for Adding Liquids to Feeds

Liquids may be added to mixed feeds in several types of mixers. Each type has advantages and disadvantages.

A double-agitator continuous mixer is used in the models since it may be used over the broadest range of applications. This mixer is usually found in large mills. However, capacities range from 2 tons up to 50 tons per hour. Many plants prefer this piece of equipment because (1) more than one liquid can be added at the same time, and (2) a larger percentage of total liquids can be added than with other types of mixers.

These units have the advantage of being easily cleaned, because the drop-bottom doors permit easy access to the interior. The time required to clean equipment is one of the production problems in feed mixing plants.

A single-agitator continuous mixer is designed for adding molasses to mixed feeds usually in the medium-size mills. Production with this mixer ranges from 3 to 30 tons per hour, depending upon the size of the mixer and the amount of liquid added. Adding less liquid permits greater production. This mixer provides high-speed continuous mixing and can be easily designed to fit into an efficient integrated production system.

Many small plants such as the 80-ton model use a horizontal batch mixer for liquid mixing. An addition of 5 percent liquid is the maximum for this mixer. Higher percentages require greater horsepower and more frequent cleanout. Materials tend to collect on the agitator and side walls of the mixer when more than 5 percent liquid is added. Horizontal batch mixers' capacities range on the average from 1 to 4 tons.

Mixing with a vertical mixer is the least satisfactory method. Less liquid can be added to mixed feeds in this equipment and the cleaning is difficult.

Liquids are added at the top of the vertical mixers. They are applied by means of a pipe ring with spouts that squirt the liquid onto the feeds. Another method used is recycling. The feed is discharged into the inlet hopper where a liquid is introduced in the stream of feed. Recycling of feed is continued until the desired amount of liquid has been uniformly applied to the feed. This method is very slow. Average capacity of the vertical mixers ranges from 1 to 3 tons; however, some vertical mixers are made with capacities well above this range.

The vertical mixer is by far the most difficult to clean. Liquids such as molasses will build up on all parts of the interior. If a large amount of liquid is added to the feed, bridging takes place. Also, small balls of feed with a high concentration of liquid may be formed. Equipment manufacturers have demonstrated that 5 percent is the maximum amount of liquid for good results.

High speed blenders are being used by more feed manufacturers to get a uniform looking, lump-free finished product. Actually this blending process tends to homogenize feed. This extra process may not be essential when a double agitator is used.

Feed blending may be obtained by using an attrition mill or a hammer mill. These units may be adjusted so particle size is fairly uniform, but all lumps are blended out. Large feed manufacturers adding a higher percentage of liquids to mixed feeds tend to pass them through a blender. Cattle feeds containing crimped grains usually bypass the blender.

